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# Changes in markers of fatigue following a competitive match in elite academy rugby union players

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**Background:** Post-match fatigue has yet to be investigated in academy rugby union players.

**Objectives:** To determine the magnitude of change in upper-body (plyometric push-up (PP) flight-time) and lower-body (countermovement jump (CMJ) mean power) neuromuscular function (NMF), whole blood creatine kinase (CK) and perception of well-being following a competitive match in academy rugby union players.

**Methods:** Fourteen academy rugby union players participated in the study. Measures were taken 2 h pre-match (baseline) and immediately post-match. Further testing was also undertaken at 24-, 48- and 72 h respectively post-match. Changes in measures from baseline were determined using magnitude-based inferences.

**Results:** Decreases in CMJ mean power were *likely substantial* immediately ( $-5.5 \pm 3.3\%$ ) post-match, *very likely* at 24 h ( $-7 \pm 3.9$ ), *likely* at 48 h ( $-5.8 \pm 5.4$ ), while *likely trivial* at 72 h ( $-0.8 \pm 3.8$ ) post-match. PP flight-time was *very likely* reduced immediately ( $-15.3 \pm 7.3\%$ ) and 24 h ( $-11.5 \pm 5.7\%$ ) post-match, while *possibly* increased at 48 h ( $3.5 \pm 6.0\%$ ) and *likely trivial* at 72 h ( $-0.9 \pm 5.4\%$ ) post-match. Decreases in perception of well-being were *almost certainly substantial* at 24 h ( $-24.0 \pm 4.3\%$ ), *very likely* at 48 h ( $-8.3 \pm 5.9\%$ ), and *likely substantial* at 72 h ( $-3.6 \pm 3.7\%$ ) post-match. Increases in CK were *almost certainly substantial* immediately ( $138.5 \pm 33\%$ ), 24 h ( $326 \pm 78\%$ ) and 48 h ( $176 \pm 62\%$ ) post-match, while *very likely substantial* at 72 h ( $57 \pm 35\%$ ) post-match.

**Conclusion:** These findings demonstrate the transient and multidimensional nature of post-match fatigue in academy rugby union players. Furthermore, the results demonstrate the individual nature of recovery, with many players demonstrating different recovery profiles from the group average.

**Keywords:** collision sport, monitoring, sports injuries

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Rugby union is a collision sport that involves intermittent high-intensity activities, including sprinting, rucking, mauling, scrummaging and tackling, that are interspersed with periods of jogging, walking and standing.<sup>[1]</sup> Observations following one,<sup>[2,3]</sup> two<sup>[4]</sup> and four<sup>[5]</sup> competitive matches suggest that the high-intensity activities and impacts sustained during rugby union match play result in acute post-match fatigue that may last for several days following competition. Fatigue may manifest as alterations in mood,<sup>[3]</sup> immune function<sup>[2]</sup> and hormone levels,<sup>[3]</sup> reductions in neuromuscular function (NMF)<sup>[3]</sup> and elevations in markers of muscle damage (e.g. an increase in creatine kinase concentration CK).<sup>[2,5]</sup>

The authors' understanding of post-match fatigue in rugby union players has been derived primarily from studies involving senior athletes. To date, no study has investigated post-match fatigue in academy rugby union players. The literature examining post-match fatigue in other junior collision sport athletes is also far less voluminous than in senior players. A *likely substantial* reduction in lower-body NMF, as measured by countermovement jump (CMJ) peak power, has been observed in elite under-18 Australian rules football players for up to 24 h following an intra-club preseason match<sup>[6]</sup> while in sub-elite youth rugby league players, reductions were reported as *likely substantial* immediately, and *possibly substantial* at 24 h and 48 h following two competitive matches.<sup>[7]</sup> Upper-body NMF, as measured by plyometric push-up peak power, has also shown *very likely* and *likely substantial* decreases at 24 h and 48 h respectively following two competitive sub-elite youth rugby league matches.<sup>[7]</sup> Furthermore, CK has been observed to peak at 24 h post-match and remain elevated at 48 h in sub-elite junior rugby league players.<sup>[7]</sup> However, no study has examined CK responses to match-play in this population beyond 48 h post-match.

Understanding the time-course of recovery following a competitive match is extremely important. Such knowledge can be applied to ensure that players have adequately recovered prior to undertaking subsequent training or competing in a later game. Failure to recover may lead to fatigue accumulation and result in injury, illness and poor performance.<sup>[2,8]</sup> Research in academy rugby union players provides scientific evidence with which to inform recovery and training practices in the post-match microcycle in this group of athletes. Therefore the purpose of the current study was to investigate the magnitude of change, and the time-course of recovery in markers of NMF, muscle damage and perception of well-being following a competitive match in academy rugby union players.

## Methods

### Subjects

Fourteen players (age  $17.4 \pm 0.8$  years; height  $182.7 \pm 7.6$  cm; body mass  $86.2 \pm 11.6$  kg) were recruited from a professional rugby union academy. Players were excluded if they had an injury that prevented them from participating in the testing or were involved in less than 75% of the total game time. The University's Ethics Board granted approval and written informed consent was acquired from all subjects along with parental consent.

### Procedures and design

A within-group repeated measures design was used to examine the magnitude of change in markers of NMF, muscle damage (whole blood CK) and perception of well-being following a competitive match between academy rugby union players. Lower-body NMF was measured using a countermovement jump (CMJ), while upper-body NMF was measured using a plyometric push-up. The extent of muscle damage was examined by measuring changes in plasma CK and perception of well-being was quantified by means of a questionnaire. Measures of CMJ, plyometric push-up, plasma CK and perception of well-being were taken two hours pre-match (baseline)

and immediately post-match. Further testing was also undertaken at 24 h, 48 h and 72 h post-match at the same time of day as baseline measures to avoid diurnal effects on performance. During the testing period, players did not engage in any training or strenuous activity in the days following the match. Players were advised on nutritional intake but no recovery protocol was undertaken.

### Neuromuscular function

Lower-body NMF was measured using mean power calculated from a CMJ, while upper-body NMF was measured using flight-time calculated from a plyometric push-up. Both of these measures have previously been proven reliable in this population (typical error = 3.1% and 4.2% respectively).<sup>[9]</sup> The CMJ and plyometric push-up were performed on a portable force plate (400 Series Performance Plate, Fitness Technology, Adelaide, Australia) that was attached to a laptop with software (Ballistic Measurement System, Fitness Technology, Adelaide, Australia) that measured ground reaction forces at 600 Hz. A standardised two-minute warm-up consisting of dynamic stretching was performed prior to the performance tests (walking lunges, squats, heel flicks, high knees, skipping, leg swings and three practice submaximal CMJ and plyometric push-ups). Following the warm-up, players performed two maximal CMJ followed by two maximal plyometric push-ups with a one-minute rest between each effort.<sup>[9]</sup>

For the CMJ, players began standing on the force platform with knees extended and feet in a position of their choice. Players were instructed to keep their hands on their hips and jump as high as possible. The depth of the countermovement was at the discretion of the subject.<sup>[9]</sup> For the plyometric push-up, Players began with their elbows extended and hands on the force platform in a position of their choice. Players were instructed to perform a push-up as quickly as possible ensuring that their hands left the platform.<sup>[7]</sup>

### Perception of well-being

A six-item questionnaire was adapted from McLean et al.<sup>[10]</sup> to rate the following: sleep, fatigue, muscle soreness (upper- and lower-body), stress and mood on a five-point Likert scale. Each item was rated from one to five in one score increments and overall well-being was assessed by adding up all six scores. Reliability of this method has previously been reported (CV=7.1%).<sup>[9]</sup> The questionnaire was administered prior to any other testing being undertaken.<sup>[10]</sup> Subjects completed the questionnaire on their own in order to prevent any influence from other players.<sup>[11]</sup>

### Creatine kinase

Whole blood samples were collected from the non-dominant hand, middle fingertip of each subject. Approximately 30 µl of whole capillary blood was collected using a plastic capillary tube (MICROSAFE®, Safe-tec, Numbrecht, Ivyland, USA) and immediately analysed using reflectance photometry (Refletron® Plus, Boehringer Mannheim, Germany). Prior to each session, the machine was calibrated using a standardised CK strip to ensure that the machine was analysing correctly. The reliability of this method has previously been reported (CV=26.1%).<sup>[9]</sup>

### Match demands

External match loads were assessed using GPS and accelerometer technology (Optimeye S5, Catapult Innovations, Melbourne, Australia). Based on individual maximum velocities established three weeks prior to the match, locomotive demands were classified for each player as: walking and standing (<20% Vmax), jogging (20-50% Vmax), striding (51-80% Vmax), sprinting (81-95% Vmax) and maximum sprinting (96-100% Vmax)<sup>[11]</sup>. However, as little distance was covered at maximum sprinting speed (1.43±4.01 m), the sprinting and maximum sprinting categories were aggregated to form one sprinting category (81-100% Vmax). Internal load was established using the session rating of perceived exertion method (sRPE)<sup>[12]</sup> within 15-30 minutes of the match on a modified Borg scale.

### Statistical analysis

Pre- and post-match NMF and CK were log transformed to reduce bias as a result of non-uniformity error. Perceptual data was analysed in its raw form. Data were all analysed for practical significance using magnitude-based inferences.<sup>[13]</sup> The threshold for a change to be considered practically important (the smallest worthwhile change; SWC) was set at 0.2 x between subject standard deviation (SD), based on Cohen's d effect size (ES) principle. The probability that the magnitude of change was greater than the SWC was rated as <0.5%, *almost certainly not*; 0.5-5%, *very unlikely*; 5-25%, *unlikely*; 25-75%, *possibly*; 75-95%, *likely*; 95-99.5%, *very likely*; >99.5%, *almost certainly*.<sup>[13]</sup> Where the 90% confidence interval (CI) crossed both the upper and lower boundaries of the SWC (ES±0.2), the magnitude of change was described as unclear.<sup>[13]</sup>

## Results

The duration of the match was 73:37 minutes. The first and second halves lasted 36:30 minutes and 37:07 minutes, respectively. The average match load (Rate of Perceived Exertion (RPE) x time) was 334±121 arbitrary units (AU). Players covered 4691±878 m during the match with an average of 74±6 m.min<sup>-1</sup>. Of the total distance, 1771±436 m was covered walking / standing, 2215±461 m jogging, 663±238 m striding and 41±40 m sprinting. Average Player Load<sup>TM</sup> was 451±102 and Player Load<sup>TM</sup> slow was 187±47.

### Lower-body neuromuscular function

Decreases in CMJ mean power were *likely substantial* immediately (-5.5±3.3%) post-match, *very likely* at 24 h (-7.0±3.9%), *likely* at 48 h (-5.8±5.4%), while *likely trivial* at 72 h (-0.8±3.8%) post-match (Figure 1A).

### Upper-body neuromuscular function

Reductions in plyometric push-up flight-time were *very likely substantial* immediately (-15.3±7.3%) and 24 h (-11.5±5.7%) post-match, while there was a *possible* increase at 48 h (3.5±6%) post-match and *trivial* changes at 72 h (-0.9±5.4%) post-match (Figure 1B).

### Perception of well-being

Decreases in perception of well-being were *almost certainly substantial* at 24 h (-24±4.3%), *very likely* at 48 h (-8.3±5.9%), and *likely* at 72 h (-3.6±3.7%) post-match (Figure 1C).

### Creatine kinase

Increases in CK were *almost certainly substantial* immediately (138.5±33.1%), 24 h (326±77.6%) and 48 h (176.4±62.4%) post-match, while *very likely substantial* at 72 h (56.7±34.5%) post-match (Figure 1D).

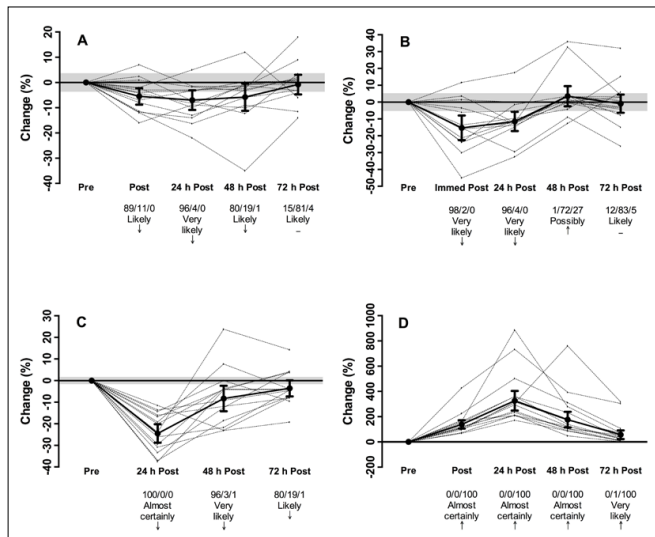


Fig. 1. Percentage changes in CMJ mean power (A), plyometric push-up flight-time (B), well-being (C) and whole blood creatine kinase concentration (D).

Data are percentage change with dotted and continuous lines representing individual changes and group mean changes with 90% confidence interval bars respectively, and the shaded area representing the smallest worthwhile change as a percentage. Probabilities of a decrease / trivial / increase values; increase ↑ decrease ↓ trivial -.

### Discussion

The present study demonstrates the time-course of recovery in markers of fatigue following a competitive match in academy rugby union players. Reductions in lower-body neuromuscular function were *likely to very likely substantial* for up to 48 h post-match, but *likely trivial* by 72 h post-match. Similar changes have been observed in CMJ peak power in senior players for up to 36 h following a competitive match.<sup>[3]</sup> Comparable findings have also been reported in other junior collision-sport athletes. For example, Wehbe et al.<sup>[6]</sup> noted *very likely substantial* reductions in CMJ mean power for up to 24 h in under-18 Australian rules football players following an intra-club preseason match, although changes were *unclear* beyond this point. Johnston and colleagues<sup>[7]</sup> also observed *likely substantial* reductions in peak power immediately post-match and *possible* reductions at 24- and 48 h following two competitive matches in sub-elite youth rugby league players.

The post-match transient reductions in NMF may be the result of central fatigue, resulting in a reduction in voluntary muscle activation.<sup>[14]</sup> Furthermore, muscle damage from repeated stretch-shortening cycle actions that occur during high-intensity running,<sup>[5]</sup> and also from the blunt trauma to the lower-limb musculature that occurs during collisions,<sup>[11]</sup> may have further contributed to the reduction in NMF.

In contrast, upper-body NMF in the present study was *very likely* reduced for 24 h post-match, with *substantial* reductions being *unlikely* beyond this point. This reduction may be attributed to the blunt trauma sustained during physical contact, which has a substantial effect on upper-body NMF.<sup>[7]</sup> Changes in upper-body NMF have not currently been investigated in senior rugby union players. However, in the previously mentioned study involving sub-elite rugby league players by Johnston and colleagues<sup>[7]</sup> *almost certain substantial* reductions in PP peak power were observed immediately post-match, while *likely substantial* reductions were reported 24 and 48 h post-match. Unfortunately a direct comparison with the present study cannot be made, as this metric was not included in the analysis due to unacceptable reliability in this population.<sup>[9]</sup>

Perception of well-being demonstrated *almost certain substantial* reductions at 24 h post-game and remained *very likely* and *likely substantially* reduced at 48 h and 72 h post-match. In senior collision-sport athletes, reductions in perception of well-being have been reported to peak at 24 h post-match and gradually return to baseline thereafter.<sup>[11]</sup> A similar trend occurred in the present study with only small (-3.6±3.7%) decreases being observed by 72 h post-match.

In the present study, CK peaked in the first 24 h post-match, which is in accordance with findings from other studies in both junior<sup>[7]</sup> and senior<sup>[5,11]</sup> collision sport athletes. Elevations in CK have been associated with damage to skeletal muscle tissue, either from direct trauma during collisions<sup>[4]</sup> or repetitive eccentric damage during high-speed running<sup>[5,11]</sup> throughout match-play. The resulting disruption of skeletal muscle integrity leads to leakage of CK into the bloodstream.<sup>[15]</sup> The results demonstrate that biochemical homeostasis had not been restored by 72 h, with CK levels still *very likely substantially* elevated (56.7±34.5%) at this time. However, the consequence of this is unclear. Given that lower-body neuromuscular recovery was evident by 72 h, the large elevation in CK at this time may reflect the rate of CK clearance from the blood,<sup>[15]</sup> and not the extent of muscle damage.

The results of the present study also demonstrate the individual nature of recovery following match-play in academy rugby union players. Figure 1 shows that even when the group mean demonstrated near full recovery, certain individuals still exhibited negative changes that were greater than the SWC. These findings emphasise that although understanding a group response provides valuable information on the recovery in the days post-match, it is important for practitioners to monitor the recovery of each individual player following competition.

A limitation of the present study is the analysis of only one competitive match. However, the total distance covered in the current study (4691±878 m) was similar to the average distances reported from five games (4470±292 m) by Venter et al.<sup>[16]</sup> in under-19 provincial players, suggesting this may represent academy rugby match demands. However, future research involving a greater number of observations is needed to further investigate the specific demands of match-play that result in post-match fatigue in academy rugby union players. Furthermore, such research may also provide insight into positional differences, both in terms of the specific match demands that cause fatigue, and the magnitude of fatigue following match play.

## Conclusion

The findings of the present study demonstrate the transient and multidimensional nature of post-match fatigue in academy rugby union players. A decrease in upper-body NMF was *very likely* for up to 24 h but was *unlikely* beyond this point, while lower-body NMF was still *likely* decreased at 48 h before returning to baseline. In contrast, perception of well-being and CK were negatively altered from immediately to 72 h post-match, although returning towards baseline at this time. Furthermore, the results demonstrate the individual nature of recovery, with many players demonstrating different recovery profiles from the group average.

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